World Summit on the Space Transportation Business

NASA Space Transportation: Safety, Cost and Performance Initiatives

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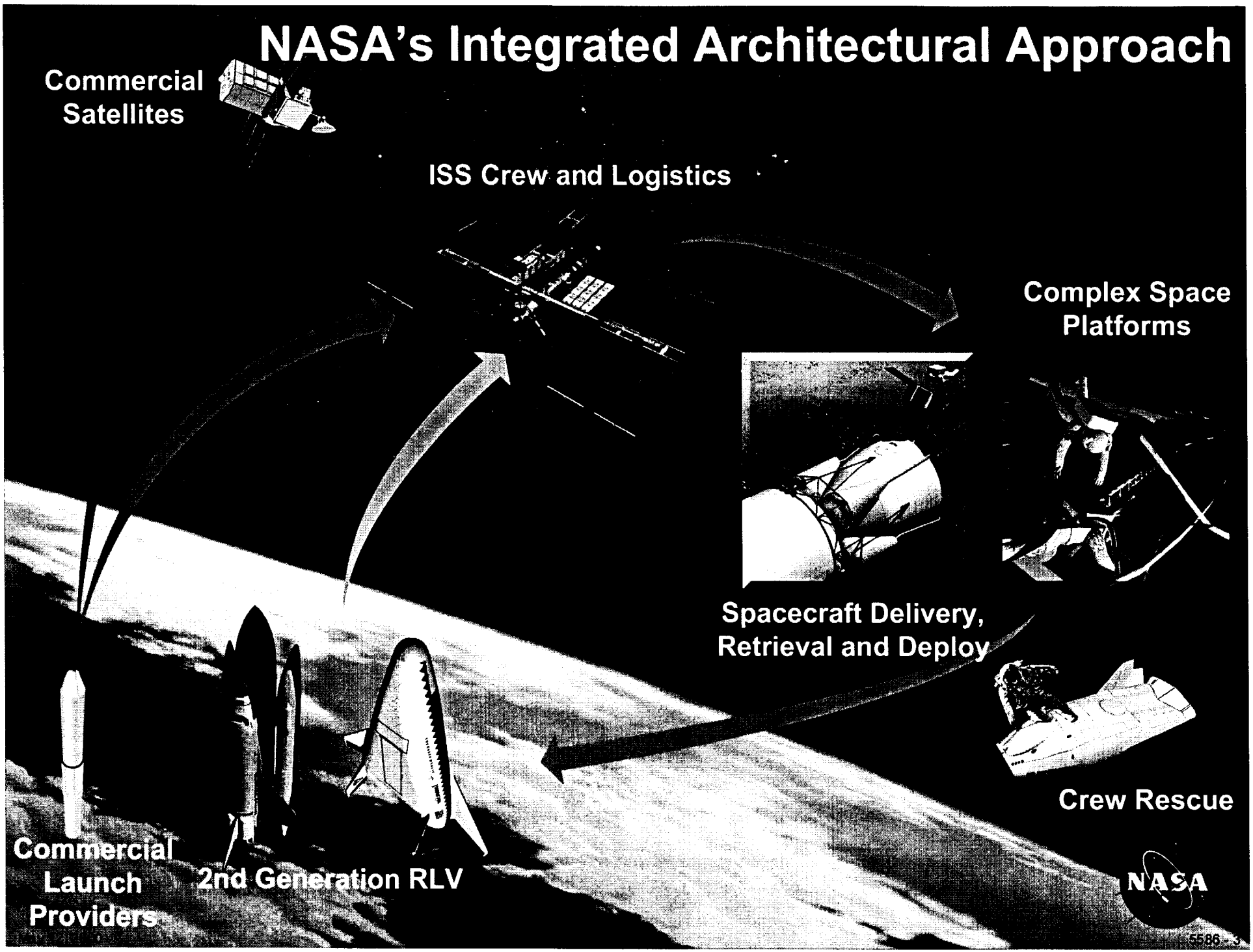
RISK BARRIER

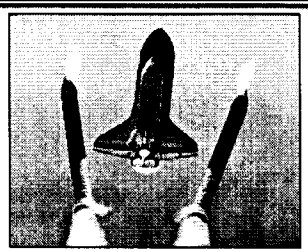
- The way to safe, reliable, affordable access to space is blocked by technical and business risk
- NASA and the Administration have developed an integrated approach to removing the risk barrier for a 2nd Generation system:

Space Launch Initiative

NASA's Integrated Architectural Approach

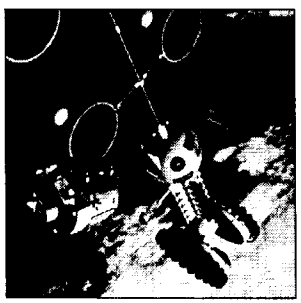


Five Point Strategy



- Shuttle safety upgrades

- Enable competition for 2nd Generation RLV

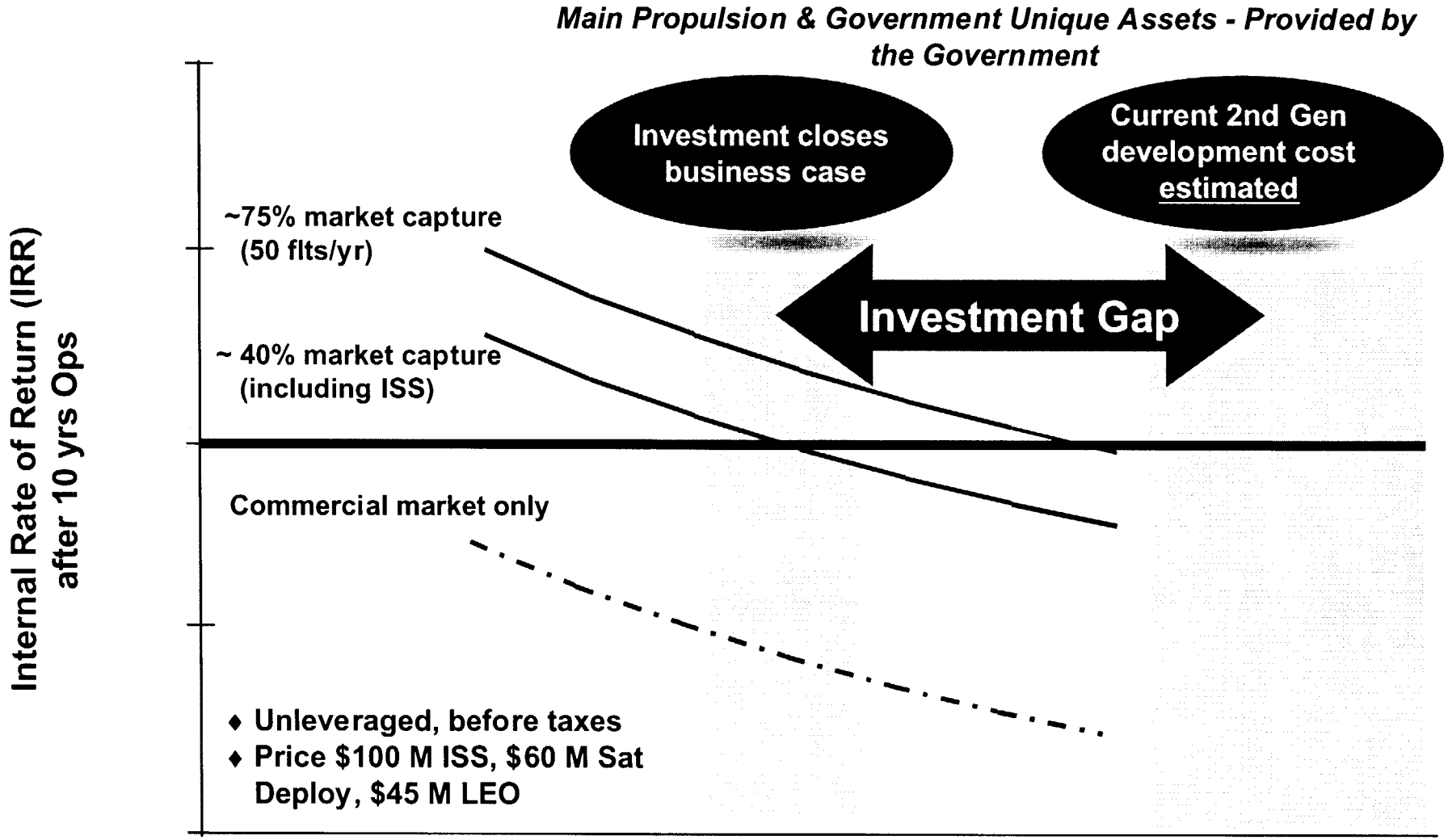


- Integrated architecture to meet NASA requirements

- Enable procurement of alternate access to ISS

- Plant "seeds" for 3rd Generation RLV

SLI Addresses Technology Investment Gap

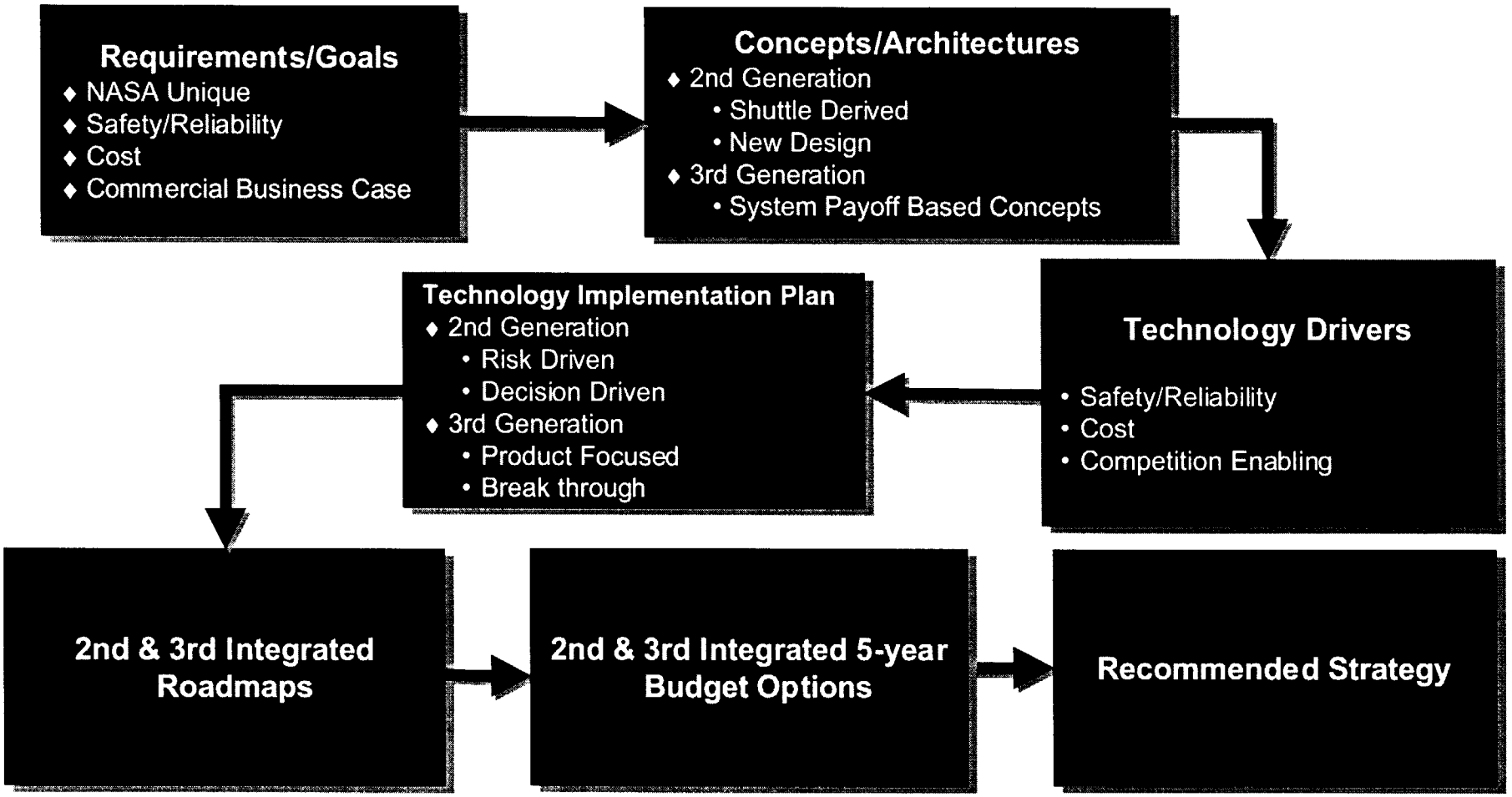


Gap Driven by Technology Need, Risk and Market Conditions

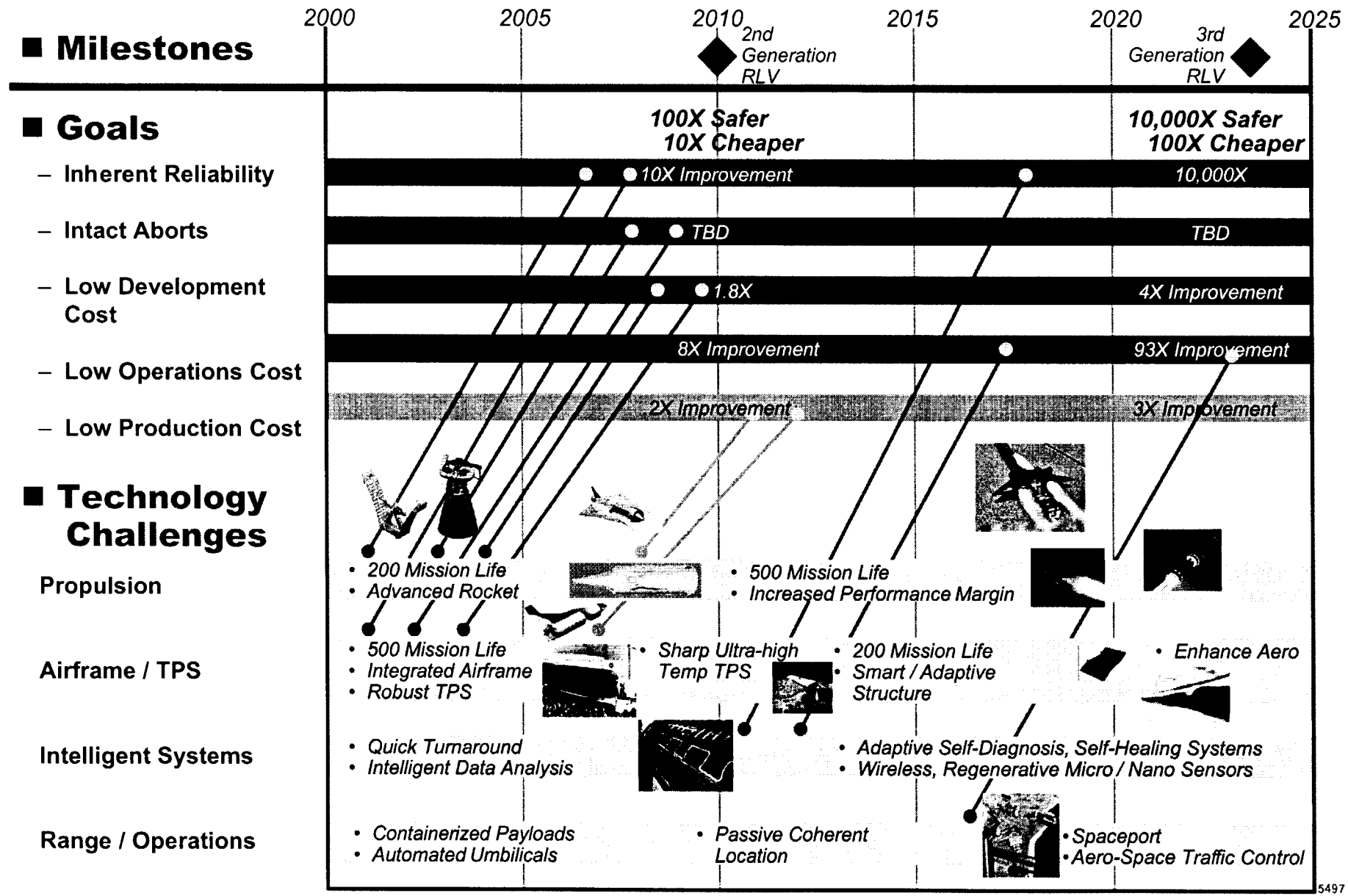
Key NASA Space Transportation Earth-to-Orbit Requirements

- **Safety/Reliability Goals**
  - Probability of Loss of Crew (LOC): 1 in approximately 10,000 missions (2nd Generation)
  - Probability of Loss of Vehicle (LOV): 1 in approximately 1,000 missions (2nd Generation)
  - Crew survivable abort capability throughout the flight profile
  - Probability of LOC/LOV: 1 in approximately 1,000,000 missions (3rd Generation)
- **Cost Goals**
  - Reduce the recurring operational cost to NASA of the space transportation architecture to $1,000 per pound of payload (2nd Generation)
  - Reduce the recurring operational cost of the space transportation architecture to $100 per pound of payload (3rd Generation)
- **Performance Goals**
  - NASA, DoD, Commercial planned missions and capabilities
  - Design reference missions for human/cargo mission capabilities through 2030
- **Maximize the opportunity for commercial development and ownership**
  - Risk and market driven
  - USG incentives are a critical part of the decision process

Technology Planning Philosophy

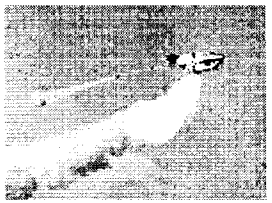


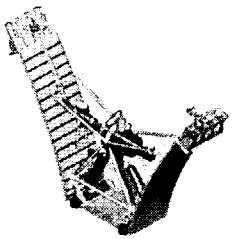
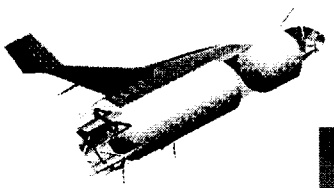
Relation of Technologies to Goals



Significant 2nd Generation Technology Drivers

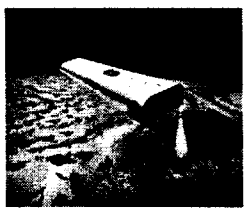
- **Crew Escape and Survival**
  - Detection, separation, ascent/descent
- **Operable, Long-life H_2/O_2 and RP/O_2 Engines**
  - 200 mission life, 100 missions to overhaul
- **Long life, lightweight integrated airframe**
  - Critical integrated cycle testing (500 missions)
- **Advanced TPS, IVHM, and Operations**
  - Quick turn vehicle with intelligent data analysis




- **Ejector Ramjet**
  - Improved performance margin
- **SHARP Leading Edges**
  - Global crossrange from orbit

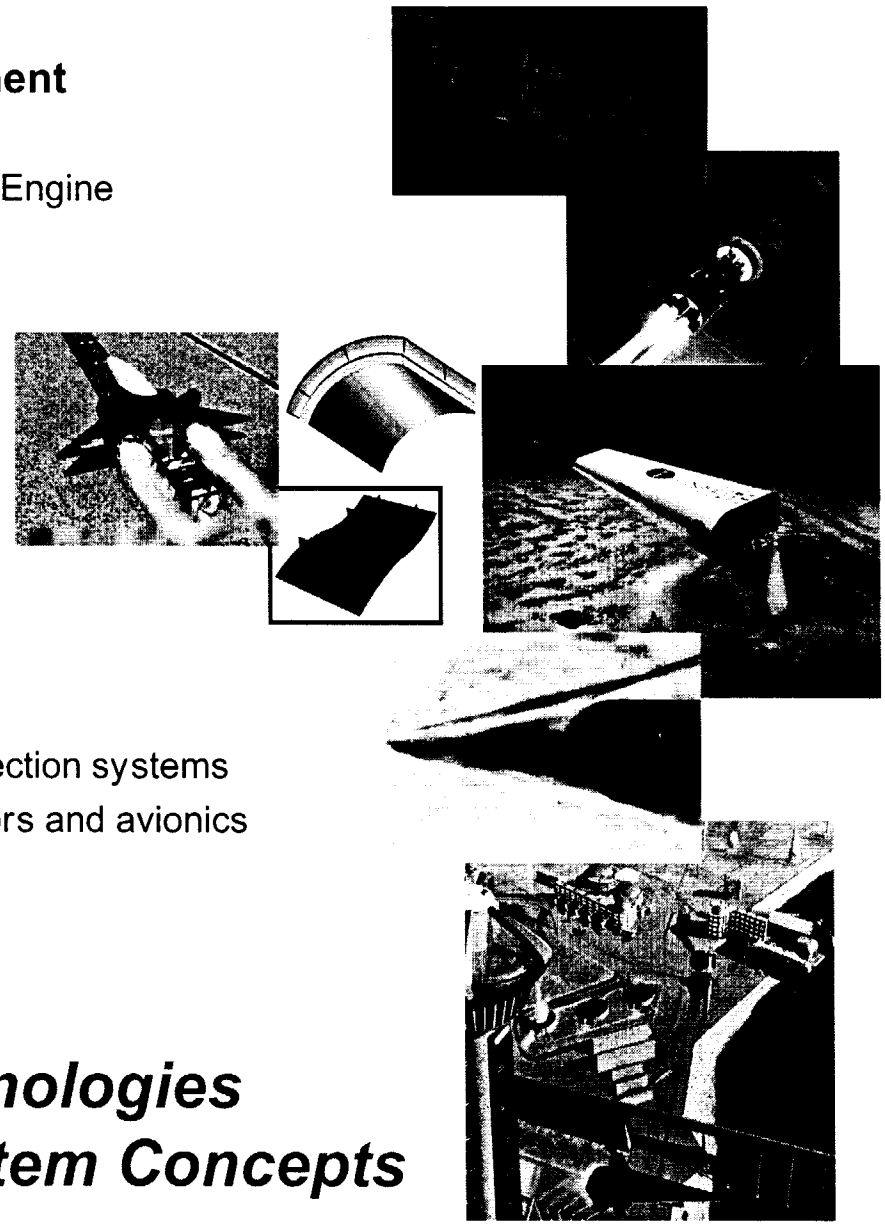
Cutting Edge for 2nd Generation

Significant Commonality Between Shuttle Derived and New Design RLV Needs

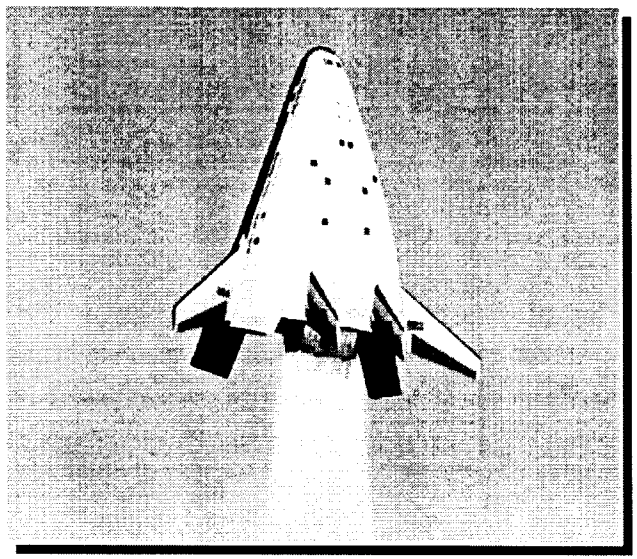
3rd Generation Technology Drivers

- **Dramatic Propulsion Performance Improvement**
  - RBCC/TBCC - Dual Mode Ramjet/Scramjet
  - Pulse Detonation Rocket Engine/Combined Cycle Engine
  - 500 mission propulsion component life
  - Magnetic Launch Assist
- **Low Drag aerodynamic structures**
  - SHARP ultra-high temperature ceramics
  - Integrated smart/adaptive thermal-structures
  - Morphing structures
  - Drag modulation through electromagnetics and flow physics
- **Adaptive Intelligent Systems**
  - Adaptive, self-diagnosis, self-healing thermal protection systems
  - Structurally integrated, wireless, micro/nano sensors and avionics
  - Regenerative sensors and system healing
  - Autonomous, adaptive control
- **Spaceport Range Operations**



Revolutionary Technologies
Driven by Goals, Not System Concepts

X-33



Program Status

- Protoflight composite tank failed during verification/ proof test in Nov. 1999
  - Failure Investigation Report: April '00
  - Program Recovery Plan: April '00
- Flight engine delivery: Dec. '00
- Protoflight tank test: Apr. - May '01
- Vehicle rollout: Feb. '02
- First flight: Fall '02
- Seven flights planned

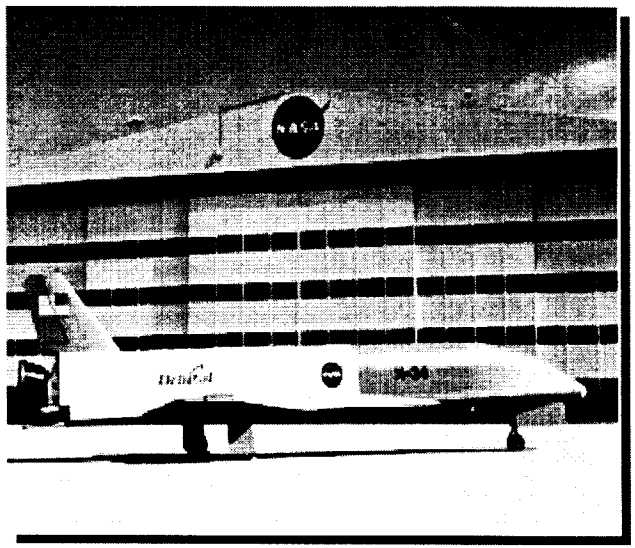
Key Objectives

- Mature the SSTO technologies required for a Next - Generation launch system
- Demonstrate the capability to achieve low launch cost and rapid launch turnaround times
- Reduce technical and programmatic risks sufficient to encourage private financing of the development and operation of the next-generation system

Key Technologies

- Demonstrate aircraft-like reusability, maintenance and scheduling
- Robust metallic TPS system
- Composite liquid hydrogen tank Mfg. processes/assembly techniques
- Linear Aerospike engine
- Vehicle health monitoring system
- Aerothermal environment prediction verification

X-34



Program Status

- Replanning completed: Apr. '00
- Reviewing to emphasize mission success:
  - Redundant Avionics/Autonomous Landing
  - Engine/MPS
  - Complete vehicle independent review
- Five drop tests beginning in '01
- 22 powered flight tests beginning in '02

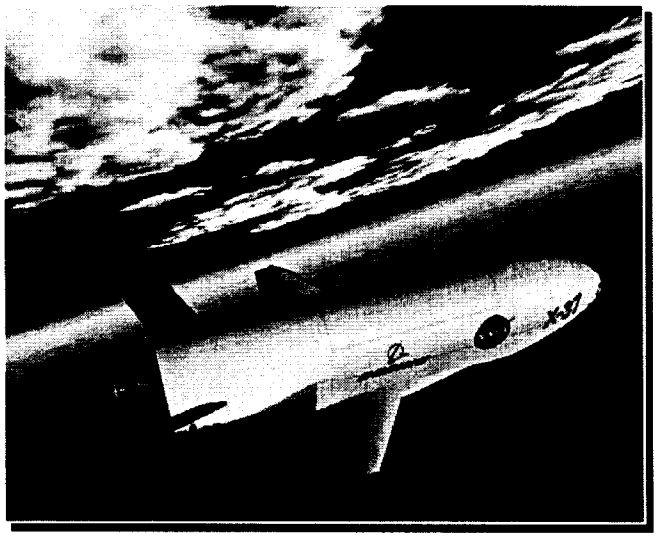
Key Objectives

- Test Bed Vehicle for demonstrating key Reusable Launch Vehicle (RLV) operations and technologies
- Focus Areas:
  - Investigation of new methods for low-cost operations
  - New RLV technologies embedded in vehicle design
  - Demonstration of hosted RLV and hypersonic experiments

Key Technologies

- Composite primary and secondary airframe structures
- Composite reusable propellant tanks
- Integrated vehicle health monitoring system
- Advanced operable TPS Including leading edge materials
- Low-cost avionics including integrated (GPS/INS) and differential (DGPS) GPS
- New low-cost rocket engine (government developed)
- Integral closed loop flush air data system

X-37



Program Status

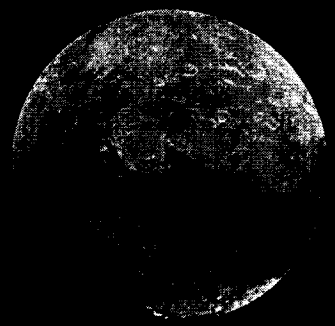
- Initial Design Review completed: March '00
- X-40A rollout mid/late Apr. '00
  - Seven drop tests beginning Aug. '00
- X-37 rollout July '01
  - Two captive carry tests - completion Sept. '01
  - Five drop tests - completion Dec. '01
  - Two orbital flights
    - » Sept. '02, Jan. '03

Key Objectives

- Successfully achieve orbit and return to Earth safely.
- Demonstrate, in representative flight environments, key technologies applicable for future RLV's.
- Provide an economical test bed capability for fully automated (unmanned) orbital, earth-entry, and landing flight demonstrations.

Key Technologies

- 32 technology demonstrations are imbedded plus eight planned experiments
- Technologies include:
  - Rapid TPS waterproofing
  - Highly operable metallic TPS
  - Durable leading edge tiles
  - Non-toxic storable propellant tank
  - Hot structures
  - High density batteries (Li Ion)



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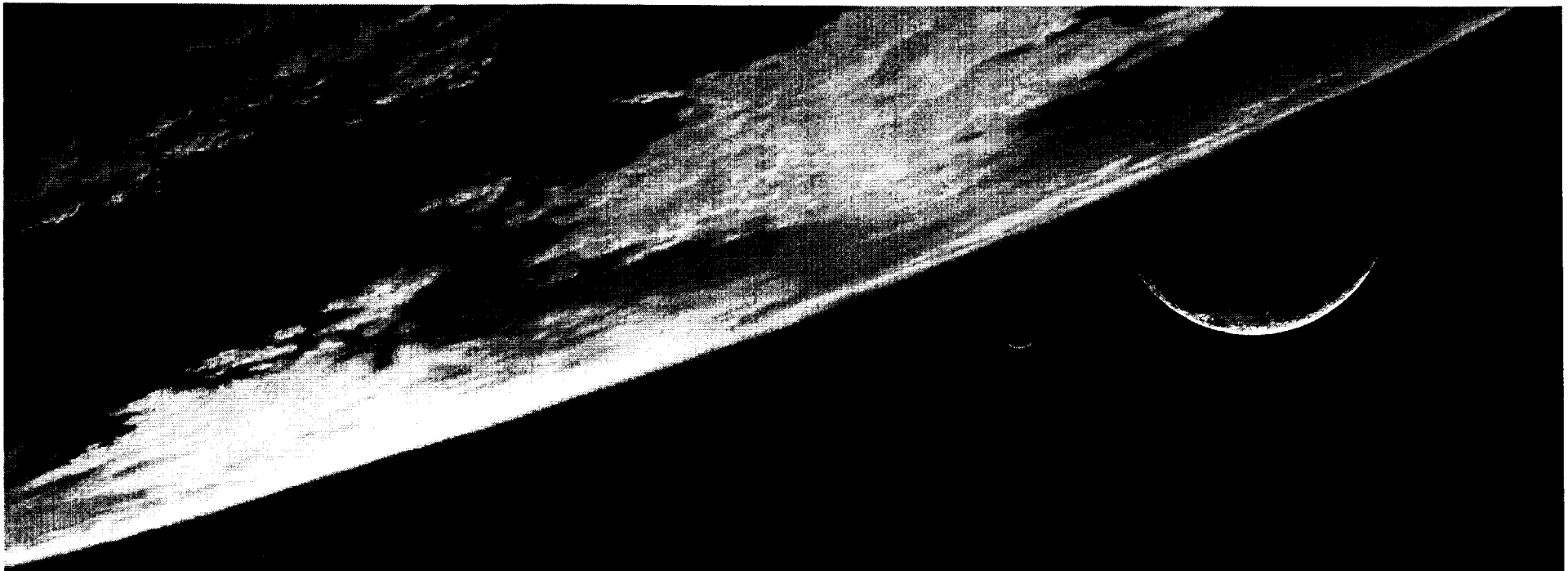
NASA



Backups

NASA

Space Transportation Directorate

Mission Definition

NASA requires an integrated space transportation architecture that fulfills a broad range of functional capabilities and mission services. These include:

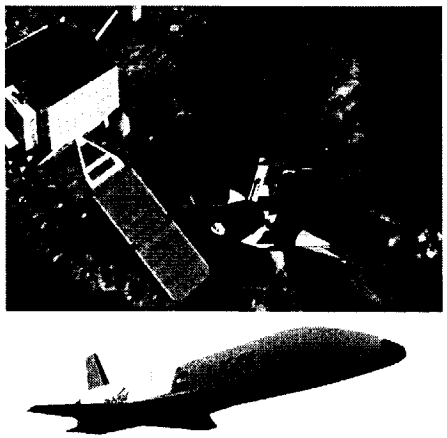
- Service the International Space Station (ISS)
- Accomplish crew rotation for the ISS
- Deliver, deploy, activate, checkout and return spacecraft and/or payloads for human and robotic mission operations
- Provide services to cargo (e.g., power conditioning, fluids, command and monitoring)
- Accomplish rendezvous and docking/berthing
- Retrieve, repair, or service on orbit spacecraft; including refueling capability
- Assemble, service, and checkout space platforms
- Reboost on orbit spacecraft and platforms
- Deorbit space debris or inactive spacecraft
- Station keep with other spacecraft
- Provide remote manipulator services for deployment and assembly tasks
- Accomplish extravehicular activities for assembly, repair, and servicing functions
- Perform emergency operations for crew and high value assets

NASA Reference Missions

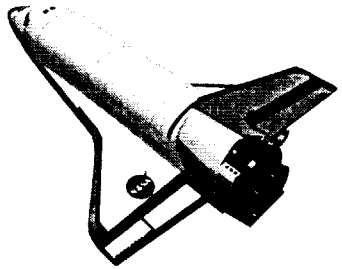
NASA is planning additional mission capabilities. These include:

- **Spacecraft or satellite payload delivery and deployment**
- **Spacecraft or satellite payload delivery, deploy, activate or return with on-orbit crew**
- **Spacecraft or satellite payload retrieval, servicing and/or return**
- **Science or technology payload platform missions**
- **ISS re-supply and crew exchange missions**
- **Complex space platform assembly & servicing**
- **Additional Excursion missions:**
  - Crew rescue
  - Polar orbit insertion

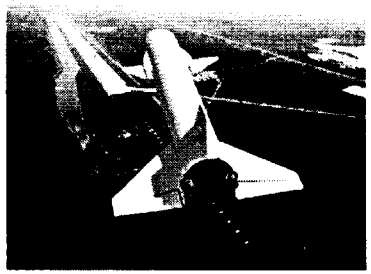
Example Pathfinder Demonstrations



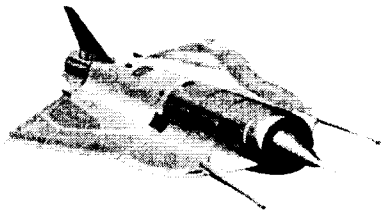
Additional X-34 and
X-37 Experiments
And Demonstrations



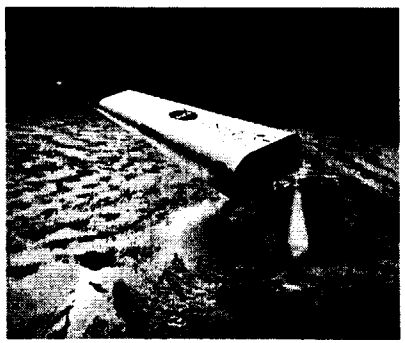
Space Shuttle
Experiments



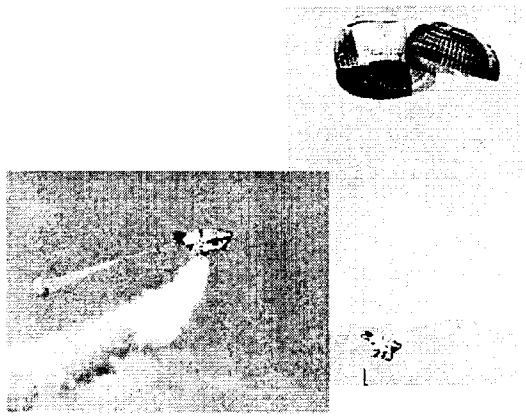
Reusable
First Stage



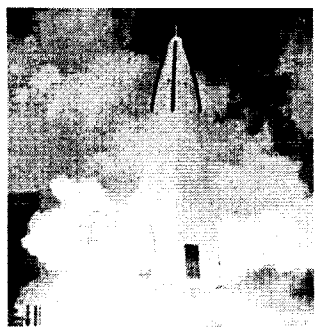
Rocket Based Combined
Cycle Experiments



SHARP Materials /
High Lift/Drag Experiments

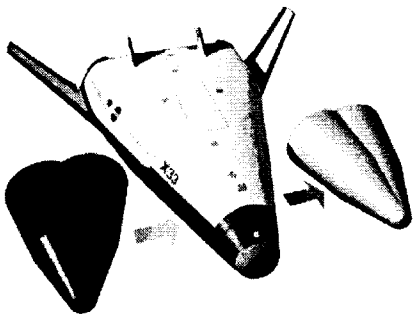


Crew Escape Demonstrations
(Narrow Envelope / Subscale)

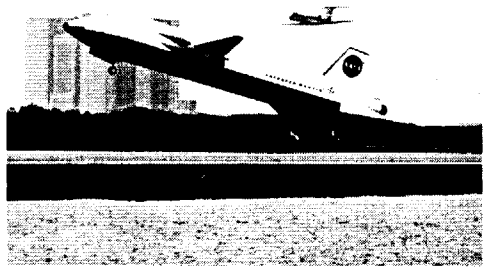


Rapid Operations
Demonstrations

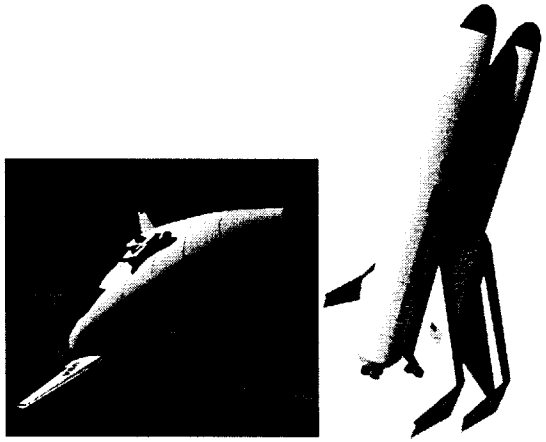
Example Trailblazer Demonstrations



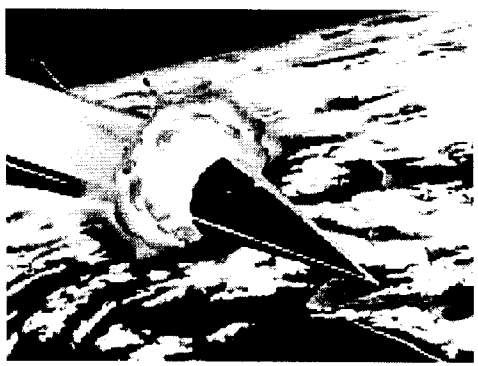
Additional X-33 Flights and Experiments (X-33B)



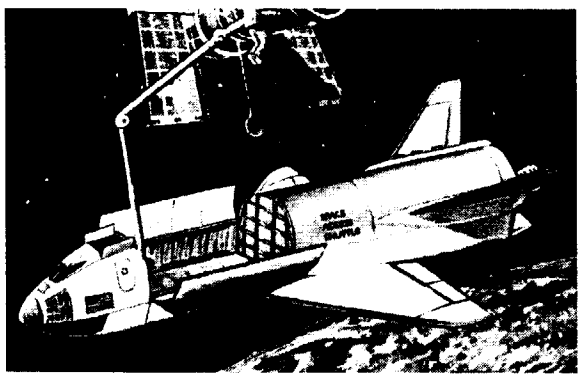
Reusable First Stage Demonstrator



Multi-Stage to Orbit Demonstrator

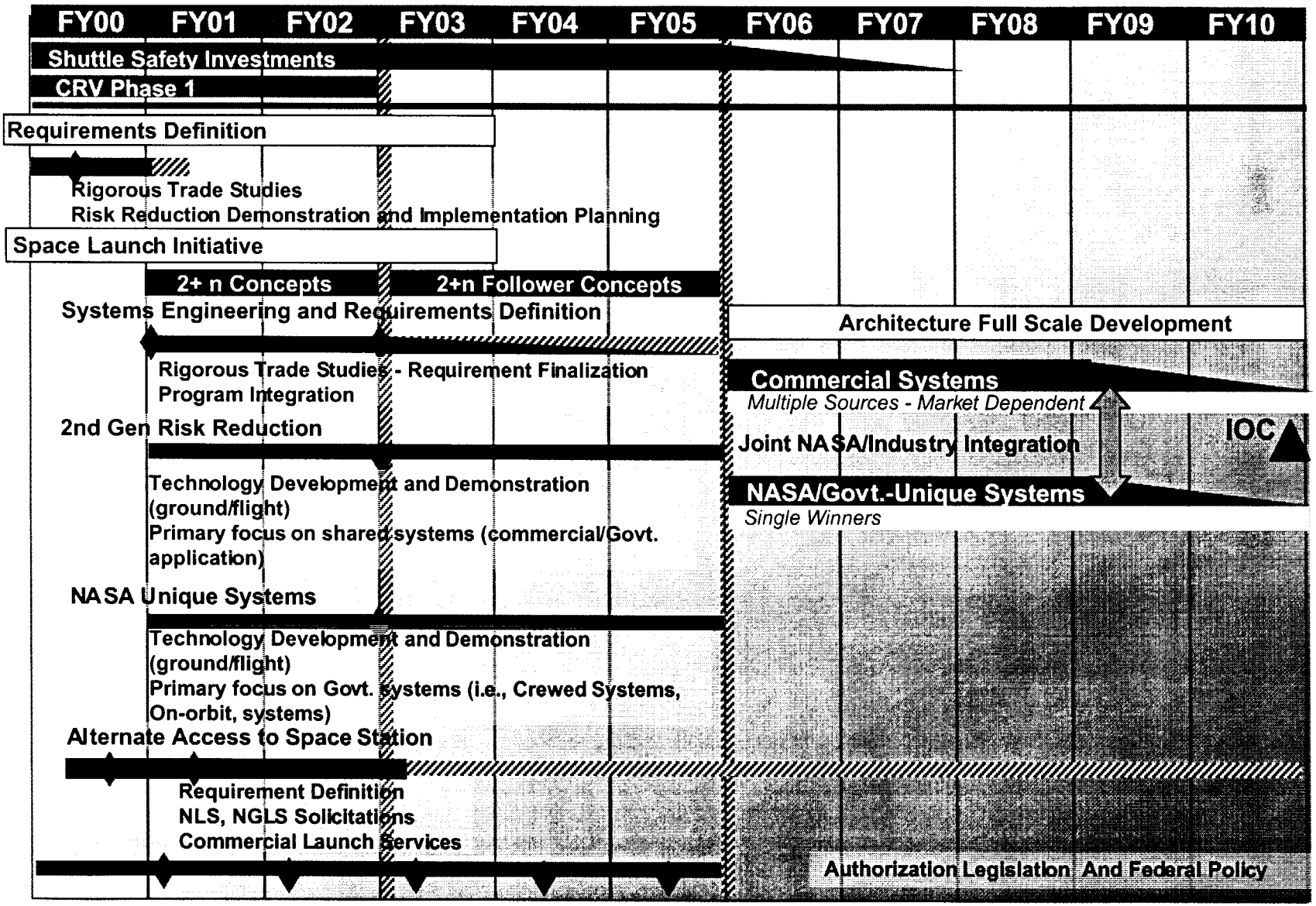


Crew Escape Demonstrations (Larger Envelope / Large Scale)

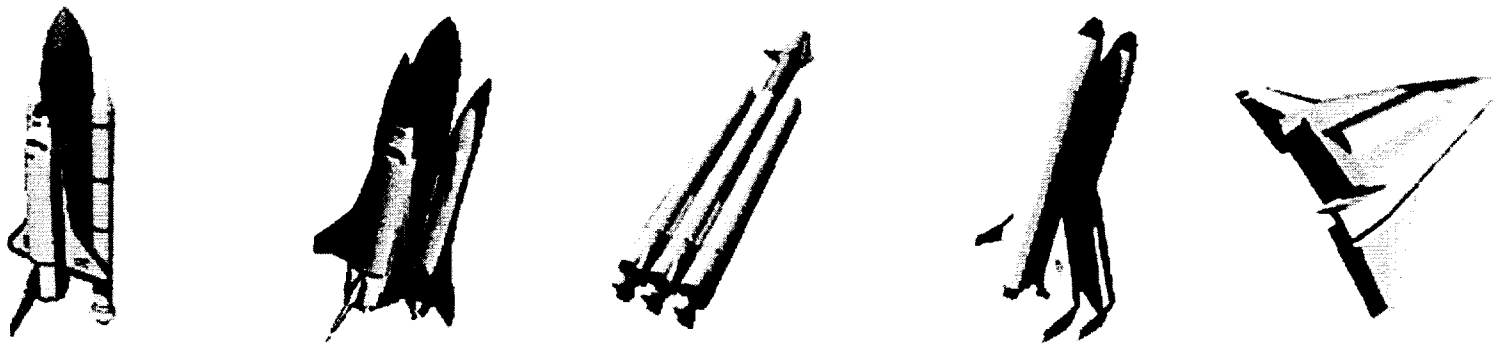


Complex Orbital Operations Demonstrations

2nd Generation Program Plan



Architecture Summary



	Architecture 1	Architecture 2	Architecture 3	Architecture 4	Architecture 5
Key Features	• Shuttle to 2020 • Phase III Upgrades	• Shuttle w/Phase III Upgrades to 2020 with a Reusable First Stage	• Replace Shuttle • EELV Heavy Launch • New Crew/Cargo Transfer Vehicle(s)	• Replace Shuttle • New TSTO Launch • Crew Transfer Vehicle/Module	• Replace Shuttle • New SSTO Launch • Crew Transfer Vehicle/Module
Key Options	• Comm'l Shuttle • Exploration	• Comm'l Shuttle • Exploration • RFS Derived Vehicles	• Partial ISS Downmass • Exploration	• Comm'l TSTO • Exploration • Alternate Access on EELV	• Comm'l SSTO • Exploration • Alternate Access on EELV
Potential New Elements	• Low Cost Upperstage • Magnum • EELV	• Low Cost Upperstage • Reusable First Stage • New Orbital Stage • Magnum • EELV	• Crew Transfer Vehicle • Cargo Transfer Vehicle • Crew/Cargo Transfer Vehicle • ATV • Magnum • EELV (human rated)	• Low Cost Upperstage • New TSTO • Crew Transfer Vehicle • Magnum • EELV (human rated)	• Low Cost Upperstage • New SSTO • Crew Transfer Vehicle • Magnum • EELV (human rated)